CDE/Hy-Gain Rotors How to Keep 'em Turning – Part 1

What is a beam without a rotor? What good is a broken rotor? W9FX has spent years repairing the CDE/Hy-Gain rotors. Here in part 1 of this two-part article, he shares his knowledge of rotor repairs. Next time he shares his knowledge of repairing the control box.

By Brad Pioveson,* W9FX

Bell-shaped rotors (or rotators, if you prefer) are as much a part of amateur radio as Morse code keys and microphones. Having the ability to remotely turn one's directional antenna and reliably knowing in which direction the antenna system is pointed when you release the switch is fundamental to being able to successfully work local stations or DX on HF, VHF, UHF, and microwave frequencies alike. What will you do when the rotor malfunctions? When—not if—it happens to you, you might find yourself grabbing the nearest ham radio dealer's catalog (or visiting the dealer's internet website), only to find that new rotor prices are a lot higher than they used to be—ouch! You might consider sending the rotor off to a shop that specializes in such work. That, too, can be a costly proposition, and you're without a rotor for days or weeks. Usually, if Murphy has anything to say about it, the rotor is either inoperative or out for repair during the biggest 6- and 2-meter *Es* openings of the past decade.

If you're looking to save both time and some money, aren't afraid to get your hands a little dirty, and have the ability to use a VOM, soldering iron, and common hand tools, this article is for you, as it will show you exactly how to take these rotors apart, install the most commonly needed new parts, and, reassemble the unit. Simple controller repairs will also be covered in Part 2. Armed with this information, some new parts, and your sweat equity, your trusty "antenna twirler" will once again be ready to provide you with many more years of trouble-free service.

For the purposes of this article, a "typical" CDE/Hy-Gain rotor will be the subject of the repair. The candidate is a CDE Ham II model. The same techniques, same tools, same parts[1], are used in the Ham M Series 3 and 4[2], the Ham III, the Ham IV, and the Ham V models. Additionally, the information also applies to the smaller TR-44, CD-44, CD-45, and CD-45 II units—with differences noted in the text where necessary. To save endless references to all these models, I'm going to refer to all of these rotors collectively as the "Ham X" series.

There are components in the Ham X rotors that need to be replaced after several years of service. This article is based on the assumption that your Ham X will need the following components replaced when you drag it onto your bench: azimuth potentiometer, terminal board, and bearings. This is not to say that other problems won't occur with your rotor. Spur gears have been known to lose teeth; final (ring) gears, especially the cast-aluminum type found in the older Ham X and CD/TR units can break; brake wedges have been known to fracture under extreme loads; and motors and/or their pinion gears will, although rarely, give up the ghost. The most common failures—and the replacement of the failed components—are discussed in this article. First, we'll examine the rotor units, then we'll look at a few of the more frequently occurring controller problems.

By the Numbers

The most common single failure item in the Ham X series of rotors is, undoubtedly, the azimuth potentiometer. Failure can present itself in a number of ways. Intermittent controller meter indications (needle "jitter") are the usual first symptom of a potentiometer problem. The design of the azimuth potentiometers has changed a little over the years, but until just the past few years the design featured a copper wiper-arm/moving-contact assembly that rode on top of the resistance wire wound around a molded, synthetic form. Oxidation of the copper wiper resulted in poor conductivity; hence, "meter jitter" was seen in many cases. Additionally, the resistance wire abraded the soft copper of the wiper, and even-

Tools
Vise, "Bench Mate," or similar device
VOM or multimeter with leads
5/16-inch diameter nut driver or socket
1/4-inch diameter nut driver or socket
Soldering iron and rosin core solder
Needle-nose pliers
Phillips screwdriver
Flat-blade screwdriver
Rags or paper towels
Degreasing compound

Parts
Azimuth potentiometer Hy-Gain part #5023100
Terminal board Hy-Gain part #5146510
10 ea. #6 × 1/2-inch stainless-steel machine screws
Bearings (98 ea. For Ham X; 49 for CD/TR) Hy-Gain part #5033501
Bearing retainers Hy-Gain part #5011300
Grease, approximately two tablespoons of white lithium or other low-temperature lubricant

Table 1. Tools and parts required for the rotor project.

*301 Kirsch Street, Benton, IL 62812
e-mail: <w9fx@verizon.net>

Photo 1. Turn the rotor upside down with the "Vee" of the mast bracket facing away from you, securing the rotor in a vise (see step 1). (All photos by the author)

Photo 2. Remove the four #12-24 screws that hold together the upper and lower halves of the rotor (see step 2).

Photo 3. Lift the brake housing (or retaining ring for the TR/CD rotors) straight up away from the rotor. The plastic spacer may come off and remain inside the brake housing (see step 3)

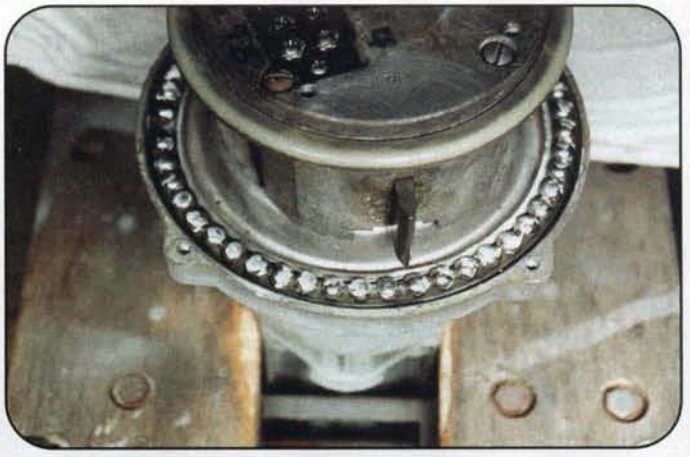


Photo 4. The plastic spacer (there is no spacer in the TR/CD units) may remain on the rotor unit, and it must be removed from the rotor or housing and set aside for cleaning and inspection (see steps 3 and 4).

tually completely ground off the end of the wiper arm, resulting in complete potentiometer failure. Hy-Gain has addressed these problems with the latest design change to the potentiometers. Since about mid-2005, the OEM potentiometers' wipers are equipped with a silver-plated rivet affixed to the end of the wiper. The rivet makes contact with the resistance wire, thus eliminating both the abrasion and oxidation problems (silver oxide is conductive).

Almost as common, and certainly the most frustrating, source of failure of these potentiometers is an operator-induced wiring error at the controller. It's easy to transpose wire colors on the 8-position terminal board and in so doing inadvertently apply 26 VAC to the potentiometer. Instant failure is the result as the potentiometer's winding melts. The smoke, however, isn't readily apparent, as it's released on top of the tower.

Another item that commonly fails, especially in older Ham X rotors, is the 8-position terminal board. That's the terminal board found on the bottom of the unit where you wire up the 8-conductor (7-conductor for TR/CD units) cable to the controller. The early units used a phenolic board with plated hardware. Few of these are still usable after 35 or 40 years of service. More modern units consist of a black plastic barrier strip. These plastic factory replacements hold up better than their predecessors, but unfortunately, they are still equipped with cadmium-plated steel screws. After a few years, or months in the case of corrosive environments, the plated hardware rusts. Intermittent or open circuits are usually the result.

The solution to the terminal board hardware rusting problem is to purchase a factory-new terminal board, and once it's in hand, remove all the screws, throw them away, and, replace them with equivalent-size (#6) stainless-steel hardware. The expenditure of a couple of dollars at the local hardware emporium is an investment that will repay you with years of future rotor service without wiring and/or conductivity issues at the terminal board!

Finally, if your rotor has been in service for some time, and especially if you live in a coastal area, your rotor will probably benefit from the replacement of its 98 (or 49 in the TR/CD series units) bearings. These plated steel balls will rust, and the aluminum/ferrous-oxide reaction can seriously erode the aluminum races of the rotor housings.

OEM Hy-Gain replacement parts are readily available from

Photo 5. The bearing set, one of two. This one is caked with dirt and grease (see step 5).

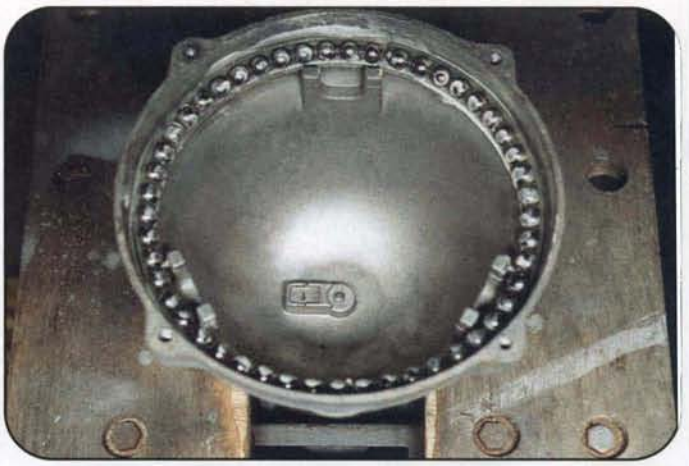


Photo 7. The upper housing with bearing set in place (see step 7).

Photo 6. The ring gear shown in place (see step 6).

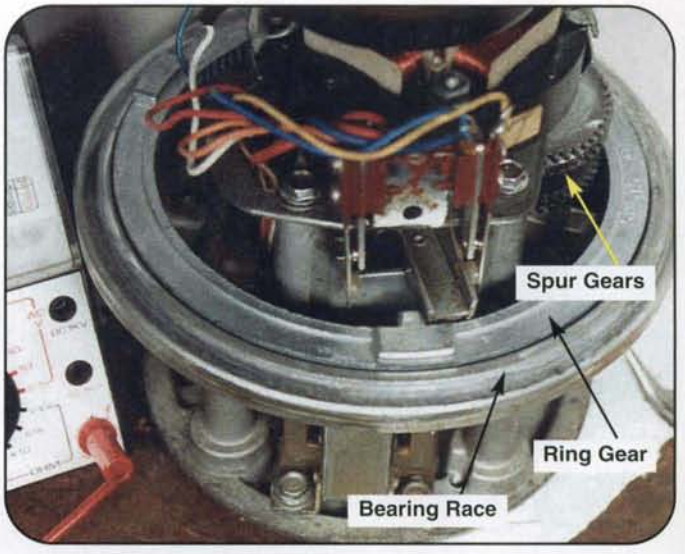


Photo 8. The spur gears, ring gear, and bearing race (see step 11).

both Hy-Gain[3] and 'The Rotor-Doc."[4] Manuals for current models of Hy-Gain rotors can be downloaded for free from the Hy-Gain website. Manuals for older CDE/CDR and Hy-Gain rotors are available for download from the BAMA website.[5]

Table 1 is list of tools and parts that will be needed for this project. *Note:* Disassembly and reassembly of the rotor will take place with the rotor in an inverted position. To do otherwise leads to a rather frustrating chase for the dozens of 3/8-inch diameter steel bearings housed within the rotor clattering to the floor of your workspace.

Following are the steps for repairing the rotor:

1. Turn the rotor upside down, with the "Vee" of the mast bracket facing away from you. Secure the rotor in a vise or similar holding device (photo 1).

2. Using the 5/16-inch diameter nut driver or socket, remove the four #12-24 screws that hold together the upper and lower halves (lower ring on the TR and CD rotors) of the rotor (see photo 2).

3. Lift the brake housing (or retaining ring for the TR/CD rotors) straight up, away from the rotor. Note that the plastic spacer may come off with and remain inside the brake housing (photo 3), or, it may remain on the rotor unit (photo 4). In either event, separate the spacer from the rotor or housing and set it aside for inspection and cleaning. (There is no spacer in the TR/CD rotors)

4. Once the brake housing (or retaining ring) is out of the way, you will see the lower bearing set exposed. Removal of this bearing set is quite easy, but if done carelessly it can lead to much frustration as you chase the 3/8-inch diameter steel ball bearings across your shop floor! Referring again to photo 4, if you carefully insert a flat blade screwdriver under the plastic bearing retainer, you can then grasp the bearing retainer with one hand. Lift it carefully, straight up. As you lift it, grasp the bearing retainer with your other hand so that you're supporting the retainer in two places, approximately 180 degrees apart. If you've done your job well, and the retainer is not damaged or stretched, the balls will stay in place.

5. Lay the bearing set on a flat surface; a workbench with a few paper towels or rags will minimize the mess (photo 5).

6. Grasp the bottom of the rotor assembly (as you're looking at it, it's now the top surface) and lift it straight up and out of the bell housing. Turn it over and place it on your work sur-

Study with the best!

Gordon West, WB6NOA and The W5YI Group

HAM IT UP! A NATIONAL RESOURCE

Technician Class

Technician Class for the 2006-10 entry-level exam! Gordo has reorganized the questions into logical topic groups for easier learning! Key words are highlighted in the explanations to help you remember the material for test success. Web addresses for more than 150 helpful, educational sites. GWTM $18.95

Tech Book & Software Package
Package includes Gordo's book and Windows program that allows you to study at your computer and take practice exams. Gordo's explanations from the book are now on the software! Free Part 97 Rule Book. NCS $39.95

Tech Audio Course on CD
Technician Theory Course recorded by Gordo walks you through what you need to know for the Element 2 exam. Great study companion to his *Technician Class* book, and an excellent study aid if you spend a lot of time in your car or truck! 4 audio CDs. GWTW $27.95

General Class

General Class **book** Upgrade to the HF bands with Gordo & W5YI! Gordo's manual for 2007-11 reorganizes all the questions into logical topic groups for easier learning. His explanations include highlighted key words to help you remember the material for test success. Audio CD is full of great operating tips! GWGM $20.95

General Book & Software Package
Study at your computer and take practice exams. Software includes explanations from Gordo's book, scores your results and highlights areas that need further study. Free Part 97 Book. GUS $44.95

General Audio Course on CD
General Theory Course recorded by Gordo is full of the sounds that bring ham radio to life! He talks you through the Element 3 theory to help you understand the material for your upcoming exam. 4 audio CDs. GWGW $29.95

Extra Class

Extra Class **book** Go to the top with Gordo! 2008-2012 book includes all Element 4 questions and answers, along with Gordo's fun, educational explanations. Full of Gordo's great memory tricks for those tough math and electronic theory questions (wait 'til you meet "Eli the Ice Man")! GWEM $24.95

Extra Book & Software Package
Study at your computer and take practice exams as the W5YI software scores your results and highlights areas that need further study. Software includes explanations from Gordo's book. Package includes Gordo's *Extra Class* book and free Part 97 Book. ECS $49.95

Extra Audio Course on CD
Extra Class Theory Course recorded by Gordo talks you through the difficult Element 4 theory to help you understand the material and get you ready for your upgrade to the top. On 6 CDs. GWEW $39.95

Order today from **W5YI: 800-669-9594** ***or on-line:*** **www.w5yi.org**

The W5YI Group P.O. Box 565101 Dallas, TX 75356 **Mention this ad for a free gift.**

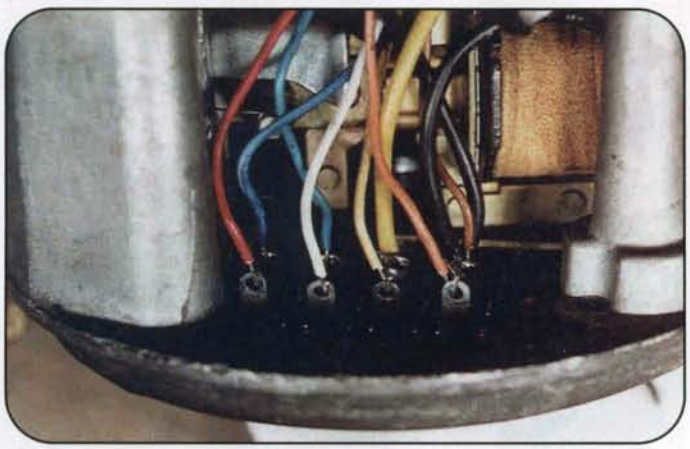


Photo 9. Terminal board and wiring viewed from the side of the rotor unit (see step 14).

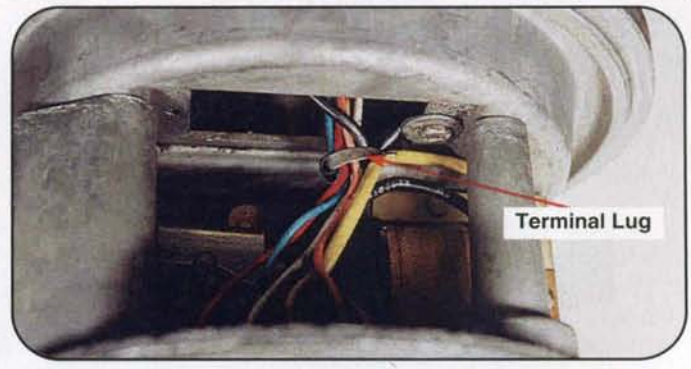


Photo 10. The terminal lug (see step 16).

face. The ring gear may dislodge itself at this time. That's OK; remove it completely and set it aside. If it stays in place (photo 6) that's OK, too, as we'll be removing it soon.

7. Using the same procedure outlined in step (4), remove the bearing set from the bell housing (photo 7).

8. The bell housing may now be removed from the vise. Remove the old lubricant with a degreasing compound. Dry the housing and set it aside.

9. Remove the old lubricant from the brake housing (or retaining ring for the TR and CD rotors). Use a stiff brush to clean the residue from between the teeth of the brake housing.

10. Set the brake housing (TR- and CD- series rotors, the retaining ring) aside.

11. Using a small, flat blade screwdriver, gently lift the ring gear out of the motor/gear base unit. You may have to move the ring gear (by manually rotating the top left spur gear) to allow the ring gear's protrusions to safely pass by the spur gear set (photo 8).

12. Clean and degrease the ring gear and set it aside.

13. Clean and degrease the rotor unit's upper and lower races and gear race.

14. Turn the rotor unit on its side to allow access to the terminal board (photo 9).

15. Over time, it is possible that the insulation may no longer be the same color as it once was; it fades over time and with exposure to the some lubricants. At the terminal strip end, blue can appear to be white, as can green, yellow, and orange! Make

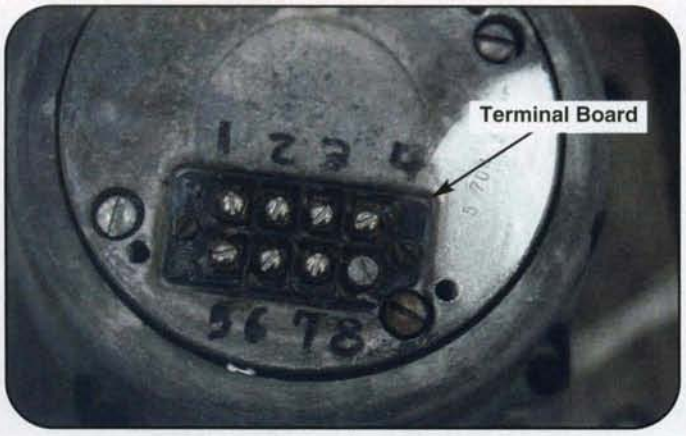


Photo 11. The terminal board (see step 18).

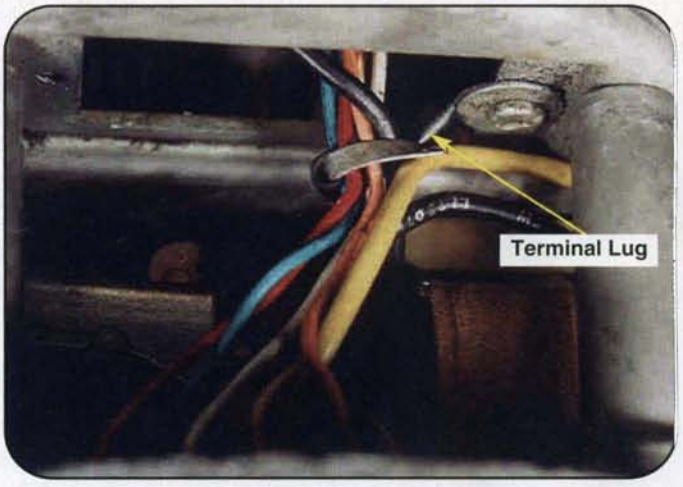


Photo 12. Secure the lugs in place with the solder lug as shown (see step 21).

yourself a chart of wire colors and terminal numbers so that you can properly rewire the new terminal strip. The color code that CDE and Hy-Gain used when they built your rotor is:

1 – Brown, Black, Black (black from rotor motor and black from brake solenoid)
2 – Large Yellow wire (from brake solenoid)
3 – Green
4 – Blue
5 – Orange
6 – Small Yellow
7 – White
8 – Red

Note that terminal 2 on TR and CD series rotors has *no* connection, and that terminal 1 on TR and CD series rotors only has two (one each, Brown and Black, wires connected).

16. Using the needle-nose pliers and soldering iron, carefully unsolder each of the wires from the terminals. If you need more room to work, you may bend the terminal lug that's used as a wire guide to allow the wires to be fanned out a bit photo 10).

17. Clean up the wire ends as necessary and prepare them for reconnection to the new terminal board.

18. Using a flat-blade screwdriver, remove the two screws that hold the old terminal board in place. Discard the old screws and terminal board (photo 11).

19. Set the new terminal board in place, making certain that the notch molded into one corner of the terminal board is situated as shown in photo 11. Install the new terminal board using the two stainless-steel, Phillips-head machine screws.

20. Working in sequence, and starting with terminal 1, attach and then solder the wires to the new terminal board.

21. Secure the wires in place with the solder lug as shown in photo 12.

22. Turn the rotor unit back upright on your work surface and orient it so that the wire connections on the old potentiometer are facing you. See photo 13.

23. Unsolder the green wire from the potentiometer. Using the needle-nose pliers, slide the insulating sleeve (if it's present) down the white wire to expose the soldered connection on the right potentiometer connection. Unsolder the white wire.

24. Using the 1/4-inch diameter nut driver or socket, remove the #6 nuts and star washers that retain the potentiometer. Note that you may have to move the wiper of the potentiometer in

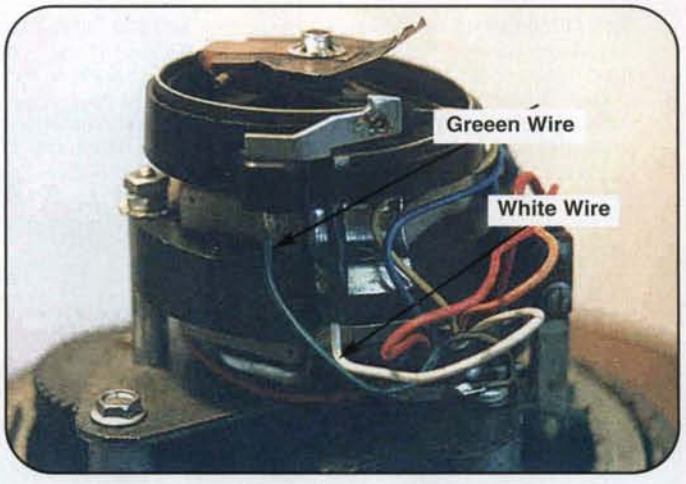


Photo 13. The green and white wires (see steps 22 and 23).

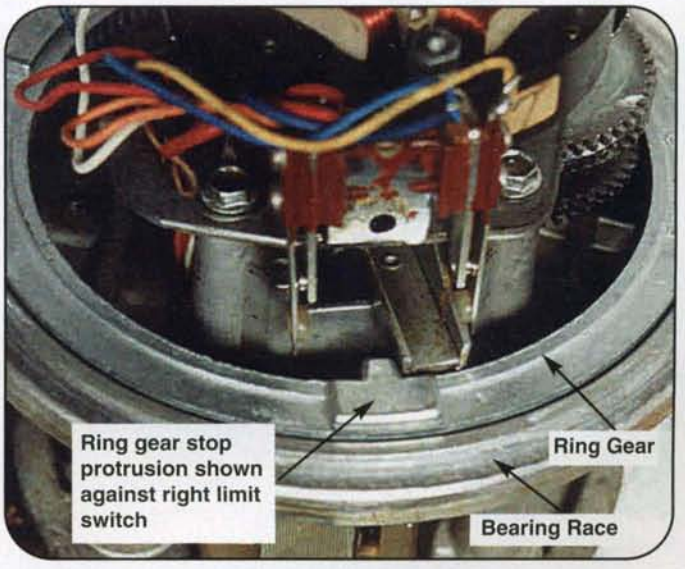


Photo 14. Set the ring gear in place such that the stop protrusion in located as shown (see step 29).

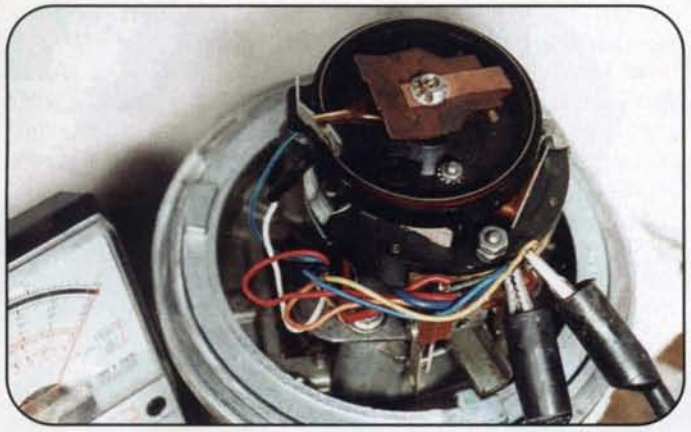


Photo 15. Set the VOM to ohms or continuity and attach the meter's leads to the terminals of the right-hand limit switch (see step 30).

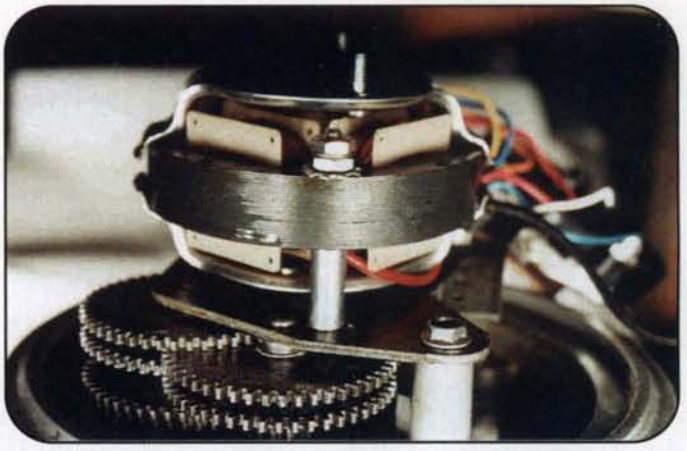


Photo 16. Turn the upper spur gear to move the ring gear (see step 31).

order to allow your socket or driver to fit onto the nuts. Once the hardware has been removed, lift the old potentiometer straight up and off the motor studs. There is a copper strap on the bottom side of the potentiometer that may resist being pulled off the motor stud. It can be "helped" with a screwdriver or with the needle-nose pliers.

25. The new potentiometer has three mounting holes. Only two of these will be used. Turn the potentiometer so that you are looking at its bottom side. There will be one hole on the left side of the potentiometer and two holes on the right. Rotate the copper grounding strap so that it aligns with the upper hole on the right side. Turn over the potentiometer and place it on the two motor studs, making certain that the copper strap is properly seated on the right-hand motor stud.

26. Secure the potentiometer using one of the star washers and nuts previously removed. Tighten firmly, but do not overtighten these nuts, as too much torque will damage the potentiometer's plastic housing! Again, you will have to carefully move the wiper arm to allow your tools to gain access to the both retaining nuts.

27. Solder the green wire to the left-hand potentiometer connection and the white wire to the right-hand connection. Note that the new potentiometer has a much shorter soldering lug than your old one might have had, and you may have to pull up a bit of the white wire to have enough to reach the new, shorter lug. Once you've completed the soldering, looking down at the top of the rotor, *rotate the potentiometer's wiper to the extreme counterclockwise (CCW) stop.*

28. Apply a thin layer of grease to the ring gear. Also, at this time, apply a thin layer of grease to the gear race—that is, the "groove" in which the ring gear rides, in the rotor unit assembly.

29. Set the ring gear in place. Try to orient the ring gear such that the stop protrusion is located as shown in photo 14. Note that some care and, often wiggling, is necessary to allow the ring gear to clear the upper spur gears and drop into place. The gear, when properly seated, should sit fully down in the race, and the ring gear's teeth should fully engage the mating teeth of the final spur gears. If you can rotate the ring gear with your fingers after you've set it in place, it isn't installed correctly. It should only move when you rotate the entire gear train!

30. Set your VOM to ohms or continuity, and attach the meter's leads to the terminals of the right-hand limit switch

Photo 17. Note that the potentiometer's wiper arm points to your left. There is a thin layer of grease around the bearing surface. (See step 33.)

Photo 18. Lightly lubricate the bearing sets (see step 37).

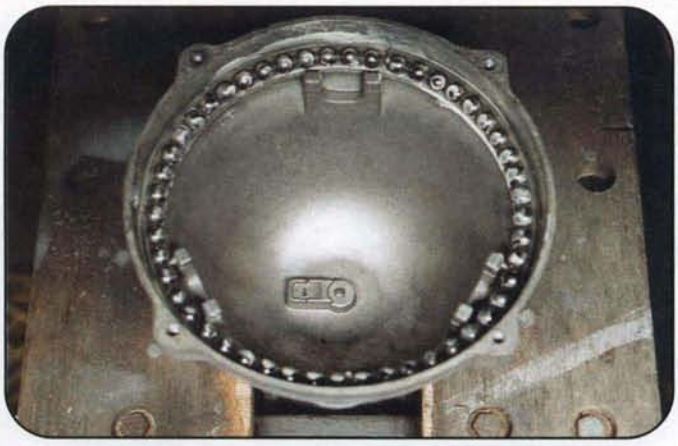


Photo 19. The bearing is set in place, flange up, and the sockets are engaged by the ring-gear mating protrusions (see step 38).

(photo 15). You should see continuity (zero, or nearly zero ohms) on the meter.

31. With your fingers or thumb, turn the spur gear shown in photo 16 counterclockwise until the stop protrusion of the ring gear contacts the arm of the right-hand limit switch and just opens it, as seen on your VOM.

32. Set the rotor unit aside.

33. Place the upper housing in the vise, again. The "Vee" of the mast bracket should be pointed away from you, and at the top of the inside surface of the bell housing, the fixture that contacts and drives the potentiometer's wiper arm should be pointed to your left. See photo 17.

34. Apply a thin layer of grease to the inside bearing surface of the upper housing.

35. Apply a thin layer of grease to the bearing race inside the brake housing (retaining ring on the TR and CD series rotors).

36. Lay out the new bearing retainers on a flat surface. The flanges of the retainers should be down. Each retainer will hold 49 ball bearings. Place one ball in each retainer slot. (For TR and CD series rotors, one bearing goes in every other slot.)

37. Using a finger, apply a very small dollop of grease on each of the balls in both bearing sets. We're looking for lubrication here, not trying to drown the bearings in grease! See photo 18.

38. Turn over one of the bearing sets so that the flange is facing up. Using both hands, carefully pick up this bearing set and set it in place inside the upper housing. See photo 19.

39. Check the rotor unit to make certain that the potentiometer wiper is still at the extreme CCW stop and that the ring gear has not moved and is still holding the RH limit switch in the "open" position. Grasp the rotor unit with both hands, taking care not to allow the ring gear to fall out of position, turn it over so that the ears of the potentiometer wiper are facing your left, and lower the rotor unit into the upper housing. The dogs on the ring gear should drop into the sockets cast into the upper housing. It may take you more than one try to accomplish this, and if so, be certain to check, before each attempt, that you have not changed the positions of the ring gear or potentiometer wiper or that one (or more) of the bearings has become dislodged from the retainer and is now lying loose in the housing! If you have successfully engaged the sockets with the ring gear dogs, you will not be able to turn the rotor unit (the part you just lowered into position); it will be solidly locked in place. If, however, the unit moves (in one direction or the other), remove the rotor base and try again, as you missed the dogs.

40. Once the rotor unit has been seated in the upper housing, apply a thin film of grease to the exposed race on the bottom of the rotor unit. Again, using both hands, set the remaining bearing set in place. This bearing set should have the *flange down* (photo 20).

41. Install the plastic spacer on the bottom of the rotor unit. See photo 20.

42. Using a finger or two, depress the brake wedge enough to slide the brake housing past it and onto the rotor unit (again see photo 20). Once the brake housing has been lowered in place, it is engaged by the brake wedge and you cannot turn the brake housing to align the bolt holes of the upper and lower housing halves. To do this, the brake must be electrically disengaged. (TR and CD series rotors have no brake. The retaining ring may simply be set in place and rotated, as necessary, to align bolt holes and the screws may be installed at this time.)

43. Attach wires or jumpers from the rotor controller's terminals 1 and 2 to terminals 1 and 2 of the rotor and disengage the brake (on Ham-II/III/IV controllers, this involves pressing and holding the center lever switch. On Ham-M controllers, this involves pressing and holding the lever switch to the left or right of center). With the brake disengaged, you may rotate the brake housing and align the bolt holes. If you have properly aligned the bearing retainer flanges and the ring gear is properly seated in the housing sockets, there should be no appreciable gap between the upper and lower housing halves of the rotor (photo 21). If, however, there is a gap of 1/16 inch or greater, disassemble the rotor, find the problem (which is usually that one, or both, of the bearing sets has been installed upside down), and correct it.

44. With the brake still disengaged, install and tighten the four #12-24 screws that hold the upper and lower halves of the rotor together (photo 22). *Do not over-tighten these screws, as failure to heed this warning will result in stripped threads in the upper housing.*

45. With the rotor still in the vise, remove power from the controller and attach the remainder of the control wires to the

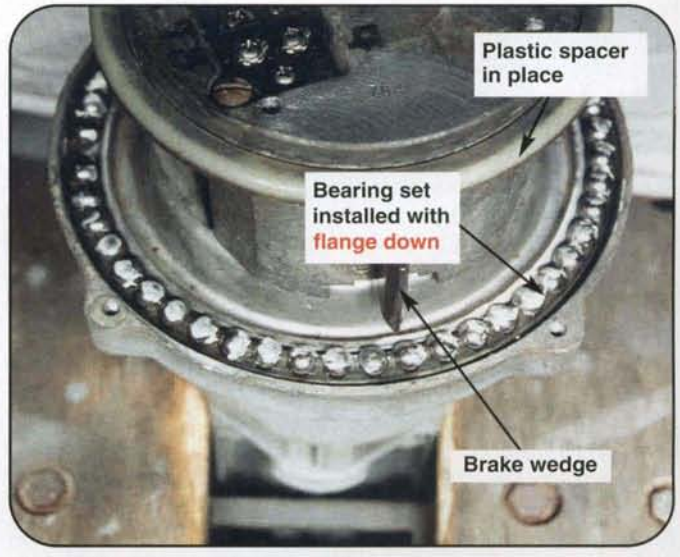


Photo 20. The plastic spacer is in place, the bearing set is installed with the flange down, and the brake wedge is in position (see steps 40, 41, and 42).

Photo 21. There is no appreciable gap between the two halves of the housing (see step 43).

appropriate terminals. Apply power to the controller and operate the rotor through a full 360-degree rotation. The meter should, initially, show full CCW ("South" on a typical indicator unit) and move smoothly to the opposite end of travel limit switch. At the end of rotation, the unit should shut itself off as it contacts (and electrically opens) the limit switch.

46. Congratulations! You've completed your work!

About Quick-Disconnects

There are those folks who believe that the convenience of having either Cinch-Jones connectors or round Amphenol connectors in the rotor with mating connectors installed on the cable outweighs the potential for water intrusion into these types of quick-disconnects. I am a strong proponent of using the standard 8-position terminal board at the rotor. Neither Cinch-Jones nor Amphenol connectors are easily waterproofed, and water intrusion into either of these connectors will lead to trouble. The circular Amphenol connectors, in particular, are troublesome. They are difficult to assemble, require a special, expensive, and, proprietary tool to disassemble (remove the contacts), and, they aren't really designed to handle the amount of current that the rotor's circuits can demand.

Here's an eye opener: I had a Ham III rotor disassembled on my bench one afternoon and wondered how high the AC current in the brake solenoid circuit would go if the brake wedge became fouled—if it couldn't move, in other words. Using a clamp-on AC ammeter, I measured 15+ amps of 26-VAC current flowing between terminals 1 and 2 of the rotor's wiring.

Photo 22. Prepare to align the bolt holes in the housing halves before installing the four housing screws (see step 44).

My suggestion, for those who wish to have a quick-disconnect near the rotor, is to use an OEM 8-position terminal board retrofitted with stainless steel hardware at the rotor. Construct a short pigtail of rotor cable. Equip one end of the pigtail with one of Press Jones's (The Wireman, Inc.) model 352 "8 pole molded connector, male and female set, heavy duty, weather proof."[6] Install the mating connector on the end of the cable that leads down the tower. Wire the 8 conductors of the rotor pigtail to the terminal board, cover the terminals and exposed copper wire on the terminal board with silicone grease (not silicone caulk!), and mount the rotor on your tower. Use spacers between the rotor and the tower mounting plate to allow water to run off and not make contact with the terminal board. For spacers, you can use stacked (stainless-steel) flat washers over the 1/4-inch diameter mounting hardware, or, you can use 5/16-inch or 3/8-inch diameter hex nuts. A 1/4-inch air gap here can make a lot of difference in the longevity of your electrical connections to the rotor. Hy-Gain also makes and sells a manufactured spacer to accomplish this task.

In Part 2 we will cover solving problems with the controller.

Notes

1. The gear trains of the various models differ, but bearings, potentiometers, and wiring are the same in all cases

2. The Ham M Series 1 and 2 rotors are unique in that their electrical wiring differed greatly from subsequent models.

3. <www.hy-gain.com>

4. <www.rotor-doc.com>

5. <http://bama.sbc.edu> and it's mirror site <http://bama.edebris.com/manuals/>

6. <http://www.thewireman.com/rotorp. html#351>

If you enjoy Amateur Radio, you'll enjoy CQ

CQ is a different kind of ham magazine. Fun to read, interesting from cover to cover. Read and enjoyed by thousands of people each month in 116 countries around the world.

CQ is devoted entirely to the things that Hams care about. It's a fine blend of technical ideas and projects, news and reviews of new Ham products and operating information, written and edited by a group of people who are absolutely crazy about this hobby!

	USA	VE/XE	Foreign Air Post
1 Year	36.95	49.95	61.95
2 Years	66.95	92.95	116.95
3 Years	96.95	135.95	171.95

Please allow 6-8 weeks for delivery of first issue

CQ Magazine
25 Newbridge Rd, Hicksville, NY 11801
1-800-853-9797
www.cq-amateur-radio.com
VISA AMEX

CDE/Hy-Gain Rotors
How to Keep 'em Turning – Part II

In Part I of this series, we looked at how to repair the most commonly experienced problems with bell-shaped CDE/Hy-Gain rotors. Despite Murphy's best efforts, not all rotor (rotator) system problems are found on top of the tower. Sometimes the problem can be found, and corrected, in the shack. In this part, we'll cover what can happen to the various styles of controllers that are used with these rotors and how to identify and repair those problems.

By Brad Pioveson,* W9FX

An often-seen post on antenna-related e-mail reflectors inquires about what kind of controller one can use with specific types of CDE/Hy-Gain rotors. The answer is an equivocal, "It depends."

The history of these rotors can be traced back to the days of the CDE Ham M-series. These first rotors were delivered with a controller that sported a single, lever-operated switch and a large meter, housed in a compact brown or black plastic case (photo 1). That single-lever switch performed all the functions needed to move the antenna remotely. When the operator pushed the lever to the left, the switch energized the rotor's brake-release solenoid while applying power to the rotor motor, turning the rotor in the counterclockwise direction and simultaneously engaging the DC circuit that turned on the indicator meter. When the operator released the lever switch, power was simultaneously removed from the DC circuit, the brake solenoid, and the rotor motor. The brake wedge, no longer held back by the energized solenoid, thus instantaneously slammed into the nearest groove in the rotor's lower housing, regardless of any movement of the antenna/mast assembly. Inertia was a diabolical enemy of these brake wedges. Hams with sizable antenna arrays mounted above Ham M rotors soon learned how to change brake wedges, as they would often shatter from the rotational torque applied to them.

There were four "series" of Ham M rotors. Series 1 or 2 rotors must be mated with Series 1 or 2 controllers. If you are unclear on that point, let me suggest you read that sentence again. Failure to heed this warning invariably results in expensive "smoke" being liberated from both rotor and controller.

Series 3 Ham M rotors featured improvements that changed the rotors into the electrical configuration still in use today. In other words, a Series 3 Ham M rotor is electrically the same as Ham II, Ham III, Ham IV, Ham V, and TailTwister rotors. The Ham M Series 3 and 4 controllers will electrically operate any of these rotors. It's not a terribly good idea to use the old single-lever controllers on these more modern rotors for the reasons outlined above. If, however, you are in a pinch, have a light load on the rotor, and are careful to avoid moving the antenna during high winds (which might add to the rotational torque on the system), you can get by with an old, single-lever controller.

The single-lever controllers will happily work without any kind of restrictions

Photo 1. Examples of three rotor controllers. The top one sports a single lever-operated switch and a large meter. The bottom two show the later additions of the direction control and brake switches (lower right in both controllers), as well as the calibration and on/off switches (upper right on both controllers). (Photos by the author)

**301 Kirsch Street, Benton, IL 62812*
e-mail: <w9fx@verizon.com>

when coupled to the TR-44, CD-45, and, CD-45 II rotors. These rotors are not equipped with brake wedges, so the lack of the ability to independently control the brake is immaterial.

The Ham M Series 5 rotor from CDE addressed the problems with brake-wedge shearing, a problem that plagued the single-lever controller owners. With this new model, CDE introduced the three-switch controller. This unit sported one push-type lever switch each for CCW and CW rotation, and a third switch to engage/disengage the brake wedge. With this innovation, CDE changed the name of their rotor to the Ham II.

Since the Ham II rotor controller was introduced, the only major changes to these controllers have been in appearance and housing styles (again, see photo 1). With the advent of the Ham IV units, point-to-point and point-to-terminal-strip wiring (see photo 2) was replaced with a single PC board that mounts to the back of the unit's meter, held in place by the meter terminal nuts (see photos 3 and 4).

The TailTwister (or T2X) controller is a special case. This unit is, in all functional respects, the same controller used in the Ham IV units (and its predecessors, as noted above), except for the addition of a couple of LEDs that are installed in the front panel. The LEDs dress up the panel a bit and offer the operator some visual feedback that CW or CCW rotation has been commanded. Truth be told, the rotor doesn't care whether or not those LEDs exist, so a TailTwister rotor can be controlled using a Ham II controller.

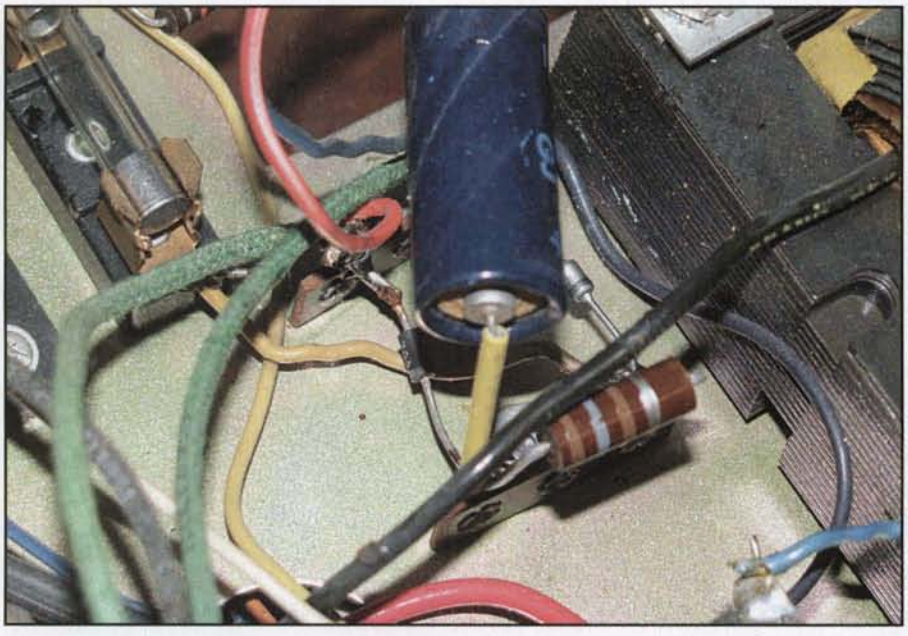
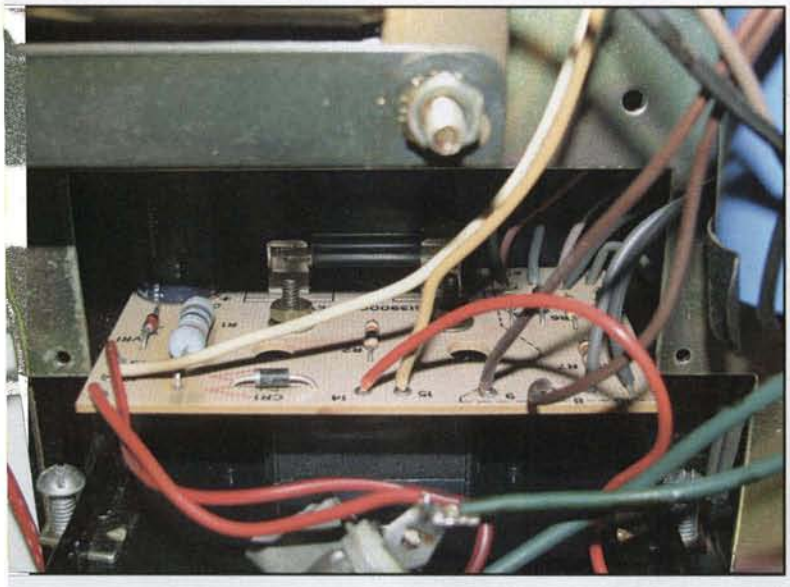


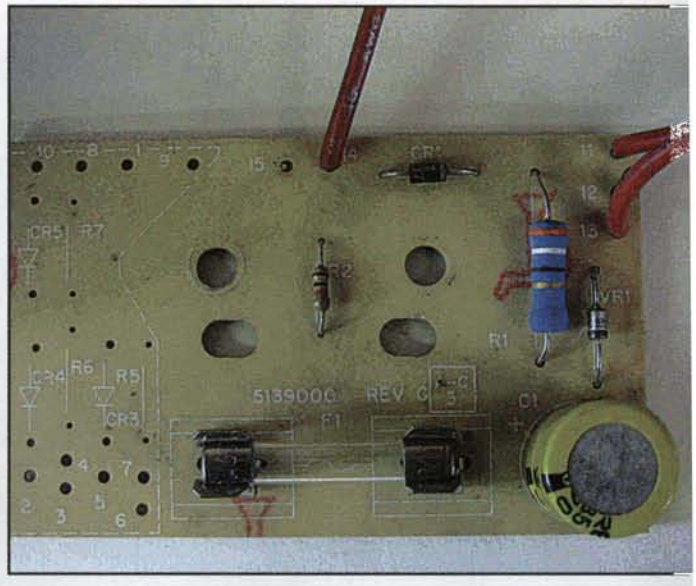
Photo 2. An example of point-to-point and point-to terminal wiring. The zener diode is wired between two terminal strips in the center of the photo. The location of the 3-amp fuse is in the upper left corner of the photo.

Theory of Operation and a Caution

Note: Some of the checks and tests require that the rotor controller be powered up—i.e., attached to the AC line and energized. Depending upon your individual unit, the AC line voltage can be either 120 VAC or 240 VAC. ***This voltage can seriously injure or kill you. Use extreme caution.*** If you are unfamiliar with the safety precautions that must be used when testing energized circuits, refer the unit to someone who is.

The controllers[1]—from the Ham M Series 3 all the way to the most modern units—provide AC and DC voltage and current to the rotor, and measure the DC current across the rotor's rheostat (azimuth potentiometer) to give the meter indication in the shack. There are two transformers in the controller. One provides the AC voltage for the motor and brake circuits, and the other is an instrument transformer from which AC volt-





Photos 3 & 4. A single PC-board, which mounts to the back of the unit's meter. The zener diode that is identified as VR-1 on the PC board is located on the left edge of the board in photo 3 (lefthand photo) and on the right edge of the board in photo 4.

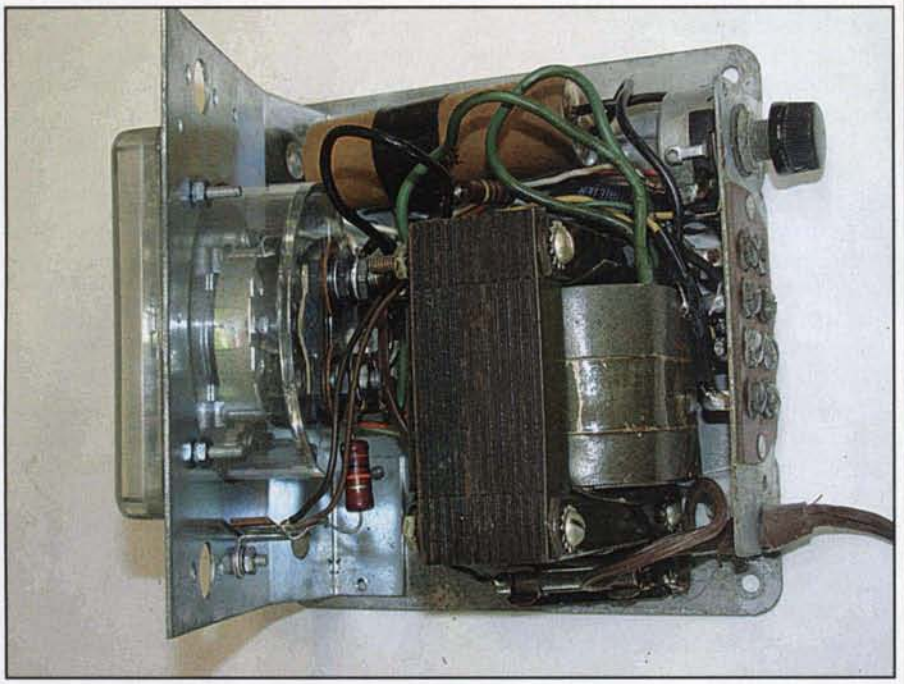


Photo 5. The location of the 3-amp fuse is in the lower edge of the photo, just below the transformer.

age is derived and rectified. This rectified half-wave DC is "regulated" by a 1N4743 13-volt 1-watt zener diode to provide the DC voltage used by the meter circuit. This zener diode is identified on the PC board legend as "VR-1." (See the left edge of the circuit board in photo 3 and the right edge of the circuit board in photo 4). In the Ham II controller, this zener is wired between two terminal strips (see photo 2).

There are two fuses in the modern controllers. One of these fuses protects the overall current demand of the rotor system. This is a 3-amp AGC-style fuse. Note that this is a 3-amp fuse, not a 30-amp fuse. In the lever-switch controllers, this fuse is located inside the housing, in a fuse holder (photo 5). In the Ham II and later controllers, this fuse is located on the back panel (photo 2). New replacement transformers and meters are expensive.

The second fuse protects the instrument transformer. These are 1/8-amp AGC-type fuses. Again, I strongly encourage you to use the proper size of replacement fuses, and I remind you that fuses do not get tired or old and simply open for no reason. If one of the fuses in your controller opens, it's time to troubleshoot the system and find out why the protective elements did their jobs.

The most common gripe among CDE/Hy-Gain controller owners is that the pilot lamp—the meter illumination lamp, if you will—fails. These are easily replaced, and are GE number 1819 lamps, available from electrical and illumination suppliers. These lamps, like all incandescent bulbs, generate heat. The plastic-housed, modern controllers have a piece of aluminum tape affixed to the underside of the top cover. That aluminum strip is placed there to prevent the heat from the pilot lamp from warping the plastic cover. If the tape is gone, it would be a good idea to replace it using aluminum duct tape. A 1-inch square piece is adequate (see photos 6, 7, and 8).

There are three options currently available for replacing a failed incandescent built with long-life LEDs. There are direct-replacement LED lamps. These can be directly substituted for the number 1819 bulb. I have one of these in one of my Ham III controllers and it does a fair job, but the cone of light transmitted by the LED doesn't fully illuminate all of the meter face. Recently, I noted that Idiom Press is marketing a small PC board equipped with three LEDs and the necessary voltage dropping circuitry.[2] This substitute for number 1819 lamps would appear to be a perfect fit, both in terms of size and application, and interestingly is priced at less than what I had to pay for an industrial LED number 1819

lamp substitute. Finally, for those comfortable with the use of hand tools, one could reuse the base of a bayonet bulb, fitting a high-intensity LED and a suitable voltage dropping resistor into the base, making your own LED substitute.

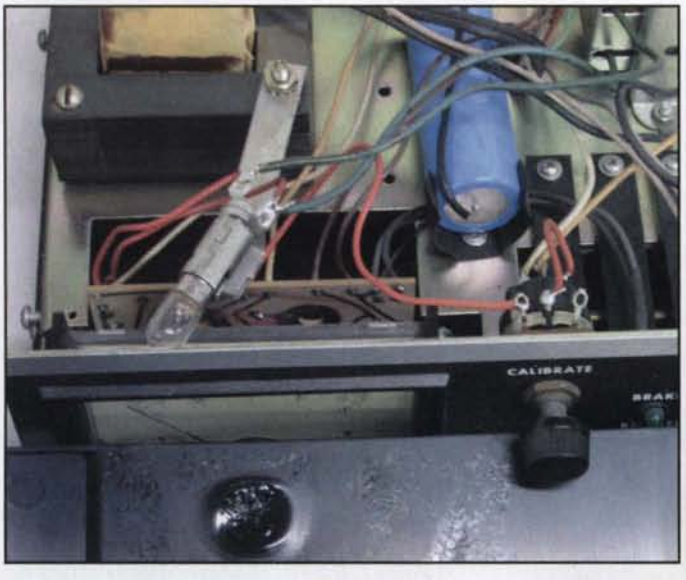
The Meter Doesn't Work

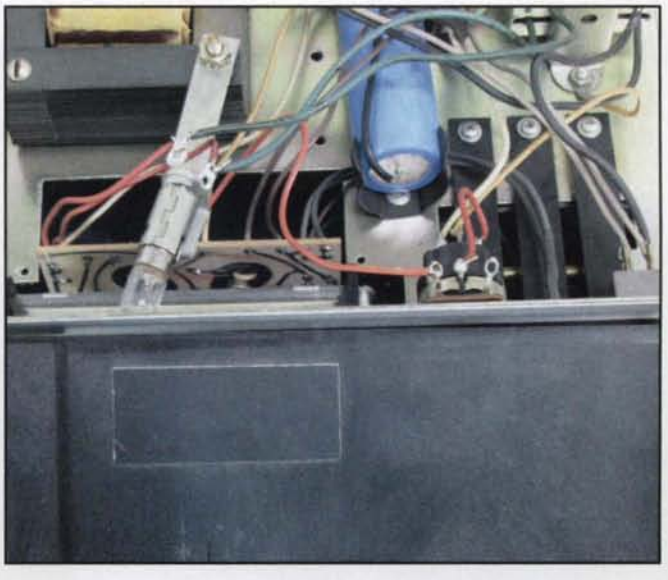
If your rotor is working, moving left and right, and the brake is operating properly but the controller meter isn't indicating, it's time to get out the VOM. Before you do anything else, make sure that the rotor cable connections to the back of the controller are secure. If everything appears well there, set your VOM to DC volts and attach your probes to terminals 3 and 7 of the controller (see photo 9). With the controller turned on (not necessary to release the brake or turn the rotor), you should see ~13 VDC across those two terminals. If you don't see that voltage, the problem is in the controller. If you do find the DC voltage to be on those terminals, the problem lies either in the cable or the rotor.

Assuming you didn't find any DC voltage coming out of the controller, you are going to have to troubleshoot the DC circuit inside the controller. Now, before you do anything else, unplug the line cord and remove AC power from the controller. Then proceed to remove the top cover from the controller. The first thing to check is the DC circuit fuse. That's the 1/8-amp fuse I mentioned in the paragraphs above. It will be located either on the PC board mounted to the meter terminals (see photos 3 and 4), or in older controllers, in a fuse clip mounted to the chassis (see photo 10). Pull the fuse out of the holder and check it for continuity. If it's open, you may be able to squeak by with a replacement fuse. EMP discharges from lightning strikes can cause these fuses to blow. If the replacement fuse pops as soon as you try the controller again, you're going to have to dig a little deeper.

If the DC voltage is present on terminals 3 and 7 of the controller and the meter is still providing no indication, turn off the controller and remove the wires from terminals 1, 3, and 7, after having noted the colors of the wires so that you can properly rewire the controller. If you have a Cinch-Jones connector equipped controller, disconnect the plug from the controller's socket. You are about to remotely check the "health" of the rotor's internally mounted azimuth potentiometer (and/or the cable between the controller and the rotor). The azimuth potentiometer's value is approximately 500 ohms.

Using your VOM in resistance-mea-





Photos 6, 7, & 8. These photos illustrate the effect of the hot bulb on the plastic cabinet. Note the bubbling of the cabinet just above the meter in photo 6 (left) and in front of the meter in photo 7 (bottom left). This effect is why it is necessary to ensure that the duct tape shown in photo 8 is securely in place. Both photos 7 and 8 (bottom right) also show the starting capacitor, which is blue.

suring mode (ohms), check for the presence of approximately 500 ohms of resistance between the wires that were attached to terminals 3 and 7. Write down your measurement.

Next read the resistance between wire 1 and wire 3. This should be somewhere between a few and approximately 500 ohms. Record this measurement.

Now measure the resistance between wire 1 and wire 7. Again, this should be between a few and 500 ohms of resistance. Record this measurement.

The arithmetic sum of these last two measurements' values should equal the total resistance as measured between wires 3 and 7.

If you read an open circuit (infinity resistance) between wires 3 and 7, the rotor cable is damaged, the connection at the rotor has a problem, or the rotor azimuth potentiometer has failed. Part I of this article discussed replacing those potentiometers.

If you read a short circuit—or nearly so—between wires 1 and 3 and wires 1 and 7, the problem, again, could either be cable, wiring connection (at the rotor), or a failed potentiometer. In this case, I would strongly suspect a failed potentiometer. Wire/terminal 1 in the Ham-series rotors is ground for both the DC and AC circuits.

The Meter Works but the Rotor Won't Turn

If your controller's meter is working and indicates the direction in which the rotor has stopped, but your efforts to move the rotor result in no movement, there are a couple of checks you can make from the shack. (*Note: The following checks will not apply to the TR-44/CD-45/CD-45 II rotors, as they have no wedge brakes.)*

• Release the rotor's brake by pressing the "Brake Release" switch or moving the lever switch left or right and listen (or, have a friend do this for you) for the resounding "thunk" from the rotor. That noise is the brake solenoid operating.

• Using your VOM in AC volts range, the cable wired to the controller, and the controller's AC power OFF, attach your probes to terminals 1 and 2 of the controller. Turn on the AC power to the controller and depress the Brake Release switch and hold it, or if you are working with one of the older, lever-style units, move the lever switch left or right and hold it. You should measure approximately 26 VAC. Release the switch and turn the controller OFF.

• If you have access to a clamp-on AC ammeter, clamp it around wire 1 or wire 2 (not both). Turn on the controller, energize the brake release, and read the AC current in the circuit. This current should be in the 1-ampere range. If, however, this current is measured at significantly more than 1 amp (I have measured them at up to 15 amps!), power down the controller and get your climbing belt.

What you just checked was the brake solenoid circuit. The controller places AC power to terminals/wires 1 and 2 to energize the solenoid. The solenoid retracts the attached brake wedge – which is, just as it sounds, a wedge of steel that mates with grooves cast into the inside of the lower rotor housing. If the voltage is

Photo 9. This photo shows the terminals in the upper right. The blue starting capacitor is also shown.

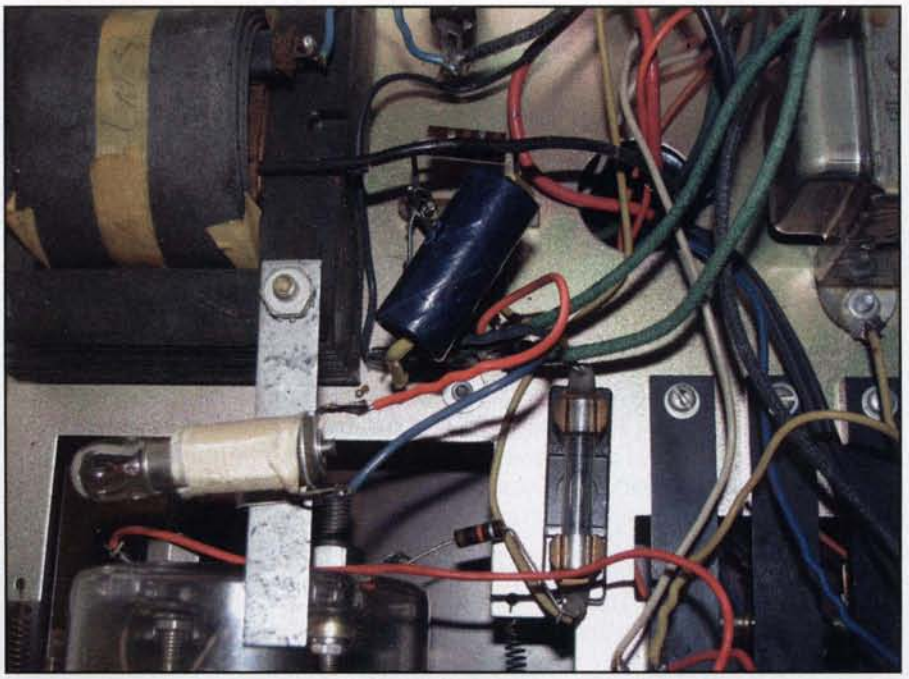


Photo 10. The location of the 1/8-amp fuse, which is located to the right in the photo.

there, and the current is within norms, the solenoid circuit is intact and the solenoid has not become mechanically jammed. If, however, the voltage is correct but the AC current is high (up to 15 amps), the solenoid, which is attached to the brake wedge, has become mechanically bound or blocked, and therefore the rotor cannot move. It's time, in that case, to get the rotor down and onto the bench for repairs.

TailTwister rotors are notorious for having the occasional brake wedge idiosyncratic problem. The brake wedges in the T2Xs from time to time tend to stick in the grooves of the lower housing. In later production years, Hy-Gain modified the profile of the steel wedge to help eliminate this problem. The "field engineering solution" (ham shack work-around) is simply to nudge the rotor, with the brake release engaged, alternately CCW and CW—i.e., rocking it a bit, to help release the wedge.

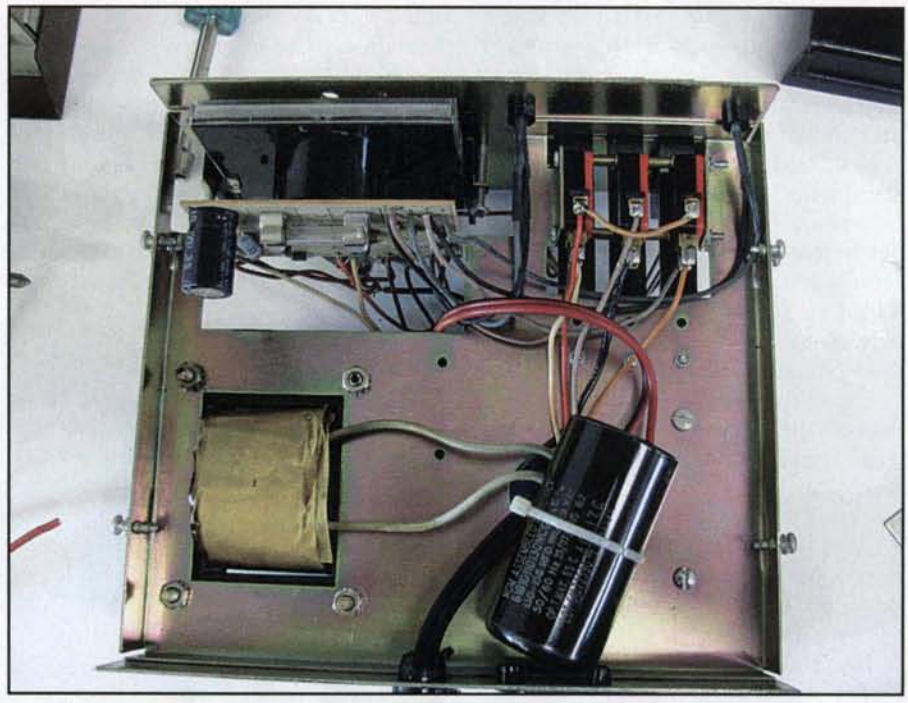


Photo 11. This photo shows the newer starting capacitor, which is black.

The Brake Circuit is OK but the Rotor Still Won't Turn

If the brake solenoid is operating, appears not to be jammed, and the rotor still won't turn, then it's time to check the motor circuitry. The motor circuit consists of a split-phase AC motor. This motor is provided with ~26 VAC by the controller. The voltage appears across terminals/wires 1 and 4 or 1 and 6, depending upon the direction of rotation.

- Remove AC power from the controller and disconnect the wiring from terminals 1, 5, and 6 (again, note colors for rewiring later).
- Using your VOM in a low ohms range and measure the resistance between wires 5 and 6. This measurement should indicate just a few ohms; the motor itself represents about 3.5 ohms of resistance, plus you'll have the resistance of the rotor cable added to that.
- Measure the resistance between wires 1 and 5, and then 1 and 6. These two measurements, added together, should equal what you read in the previous test.

If the resistance readings are in the ballpark, good news: It would appear that the motor, and cable, are electrically intact.

- Reconnect all rotor cable wires to the controller.
- Set your VOM to AC volts and attach your probes to terminals 1 and 5.
- Energize the controller, release the brake, and press the CW (right) rotation switch. You should see approximately 26 VAC indicated on your VOM.
- De-energize the controller and attach your probes to terminals 1 and 5.
- Energize the controller, release the brake, and press the CCW (left) rotation switch. You should see approximately 26 VAC indicated on your VOM.
- De-energize the controller.

If your controller passed these tests, and if your controller is over four or five years old, it is possible that the motor start capacitor, which is housed in the controller, has failed.

Motor Start Capacitors

Every CDE/Hy-Gain rotor controller has a motor start capacitor wired into the circuit (see photos 5, 7 through 9, and 11). This capacitor is located inside the controller, thankfully, and not inside the rotor. The first signs of an aging (and thus failing) motor start capacitor is that the rotor will begin to move sluggishly. If your rotor used to turn smartly and, say, make a full revolution from stop to stop in 70 seconds but the unit has started slowing down, your motor start capacitor needs to be replaced.

These capacitors can be obtained from most electrical-supply shops and probably all motor-rebuilding shops. Industrial suppliers such as W.W. Grainger, etc., have them as well, and they aren't expensive. These non-polarized capacitors used to be housed in paper sleeves. Modern versions are housed in plastic tubes. Put another way, the new ones are substantially larger in physical size than their older cousins (see photo 11).

The value of these capacitors is not critical. When the controller was built, the factory installed 120–140 µF capacitors. These days, the 136–156 µF, 110–125 VAC units are the available replacements. Both Mallory and Sprague manufacture these capacitors.

Squeezing the larger capacitors into the controller housing can be a little problematic. Depending upon the type and age of your controller, you may find the original capacitor retained in a spring clip installed on the upper chassis of the controller. The new capacitors are too big to fit into that clip. As an alternative, you can squeeze a new capacitor into the controller under the chassis. I have successfully used cable ties and an adhesive-backed cable-tie retainer to keep the capacitor in place (again, see photo 11).

If you're using one of the older, lever switch controllers, it's not possible to easily fit the new capacitor into the controller's housing. You can, however, mount it external to the controller using a cable-tie/tie-point arrangement to secure the tubular capacitor in place. In this case, the wiring can be tied to the screws of the terminal board.

Wiring the new capacitor into the circuit couldn't be easier. There are only

two connections to the capacitor, and it's non-polarized. Using number 16 or number 14 insulated wire, solder one wire to each of the two capacitors' terminals. Solder the other ends of these wires to terminals 4 and 8, respectively, on the backside of the controller's terminal board or C-J connector.

Another interesting motor-start capacitor mounting alternative is taken from the pages of contest operators' e-mail reflector archives. Some of the contest crowd, specifically those with towers located a long way from the station (and rotor controller), have remotely mounted these capacitors, placing them (in a weatherproof container) under the tower's rotor shelf. That negates the need for using 8-conductor rotor cable, by the way. If the capacitor is remotely mounted, you can use less-expensive 6-conductor cable.

Transformers and Meters

Transformers can fail. As noted previously, there are two of these in the controller. One is used to step down the AC primary voltage to the ~30 VAC used by the motor. The other transformer is used exclusively for the DC part of the circuit—i.e., for the metering. Testing a transformer involves (with the controller disconnected from the AC line!) performing resistance checks. The primary wiring of each transformer should measure continuity from end to end. The secondary circuit of each transformer should measure continuity from end to end. There should be infinite resistance measured between the primary and secondary windings of each transformer.

Most often when transformers fail, the transformer will not pass the "sniff test." Transformers that have developed shorted windings generally do so in a dramatic fashion, and the odor is unmistakable.

The meter in your rotor controller is a precision instrument, and testing of the meter with a VOM, depending upon your VOM's open-circuit voltage, can actually cause the meter to fail. The most common cause of meter failure, by the way, is not electrical; it's mechanical. Debris, dust, particles or bits of wiring, solder, insulation, etc., can find their way into the meter movement. Gentle application of air, such as from a lens-cleaning "puff brush" sold for cleaning optical lenses, won't do damage. Using a can of compressed carbon dioxide, such as that currently sold for cleaning computer keyboards, etc., or a blast from an air hose attached to a compressor, can, however, destroy a delicate meter movement in short order.

Meters can also suffer from a residual static charge. If your controller's meter seems to "hang," never returning to zero, or is stuck in mid-range, a very small squirt from a water spray will neutralize the static electricity charge and will free up your recalcitrant indicator.

Replacement transformers and meters are available, with some caveats, from Hy-Gain. As there are so many different styles of controllers, not all meters are available, and a call to Mississippi (1-662-323-5263) will resolve the issue. They are not cheap. Transformers are readily available, although case styles and, in the case of instrument (DC circuit) transformers, the modern OEM parts now have dual primary windings. Likewise, transformers are not cheap, either.

Keep in mind that used CDE/Hy-Gain controllers abound at flea markets and via the various internet swap and auction sites. In many cases, one can purchase a complete, operating, used controller for less than the cost of the more expensive replacement parts. Of course, the used controller may need a new motor start capacitor.

Conclusion

In Part I of this series you were introduced to the basics of CDE/Hy-Gain rotor repairs. In this part (Part II) the most commonly experienced problems with rotor controllers have been discussed, and some troubleshooting hints and tips have been presented to you.

Again, whatever tests you make, whatever repairs you undertake, always keep your safety foremost in mind. ■

Notes

1. Schematics and manuals for currently marketed controllers are available for free download from the manufacturer at: <http://www.hy-gain.com> and for the older units at: <http://bama.edebris.com/manuals/>.

2. Go to: <http://www.idiompress.com/illuminator.html>.

NEW! High Performance Transverters

50, 144, 222 MHz
20 - 25 W

NEW!
432 MHz
Transverter

Our new XV Series transverters work with any transceiver that covers the 28-MHz band, including our K2 and K2/100 (which display the actual operating frequency). Multiple transverters can easily be daisy-chained to a single IF transceiver.

- Low Receive NF (typically 0.8 dB)
- High dynamic range front end (+17 dBm mixer)
- Single-port and dual-port IF connections
- From -20 dBm to 8 W Drive
- Sequenced keying output
- Built-in 10-segment LED wattmeter
- Stackable, low-profile cabinet (1.3"H x 7.8"W x 8.3"D)

XV50, XV144, XV222, and XV432 kits
Optional crystal oven, XVOVN

Visit our web site for details on all of our products.

See Us at Dayton Booths 196, 197, & 198

ELECRAFT
www.elecraft.com

sales@elecraft.com
Phone: (831) 662-8345
P.O. Box 69, Aptos, CA 95001-0069